April 11, 1967 N. LAING 3,313,342

BLOWERS

Filed Feb. 4, 1966 2 Sheets-Sheet 1

FIG. 1.

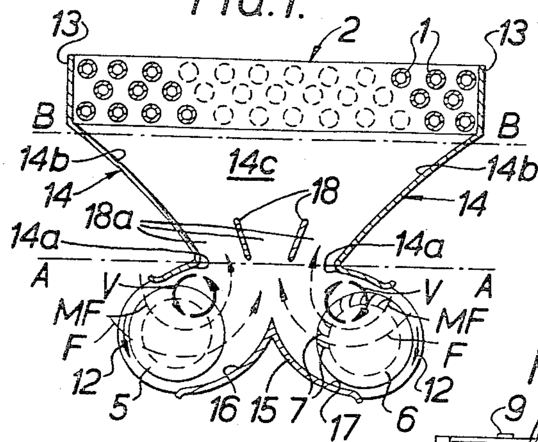


FIG. 2.

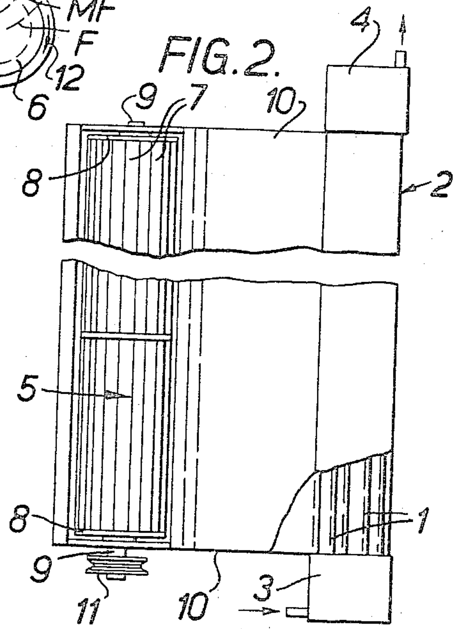
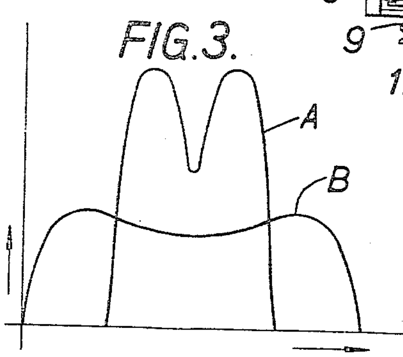


FIG. 3.



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2 Sheets-Sheet 2

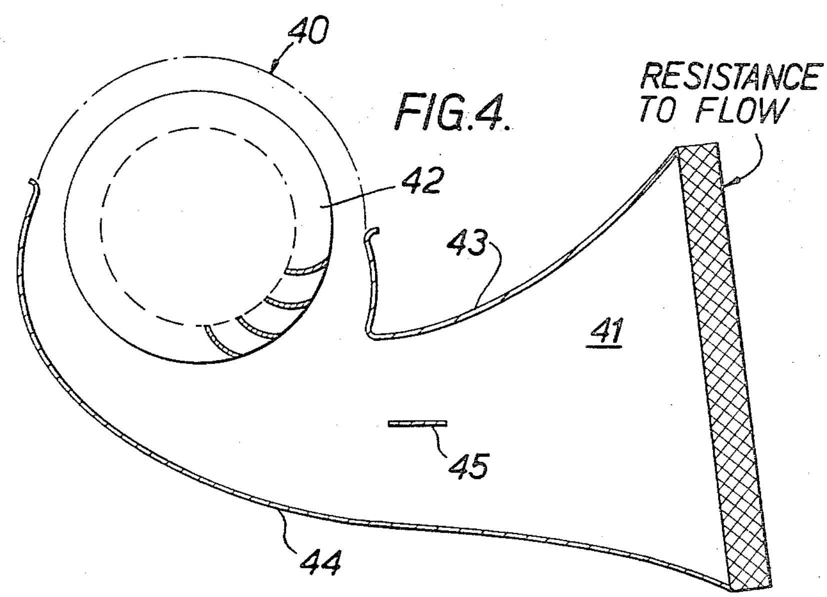


FIG.4.

FIG.5

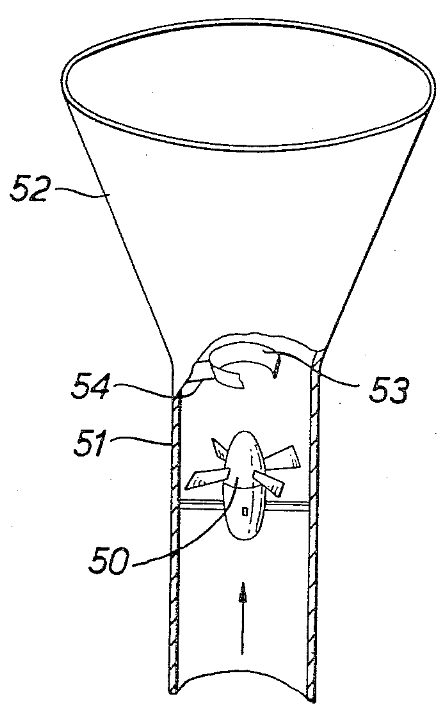
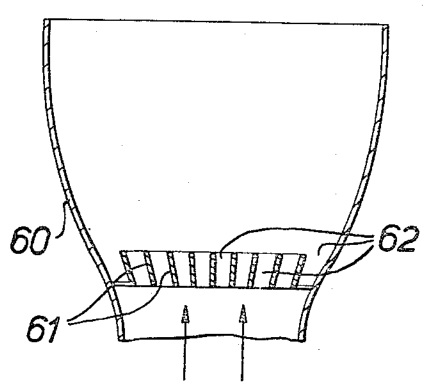


FIG.6



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3,313,342
Patented Apr. 11, 1967

3,313,342

BLOWERS

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Filed Feb. 4, 1966, Ser. No. 525,040
Claims priority, application Great Britain, Apr. 19, 1962, 15,401/62
8 Claims. (Cl. 165—124)

This invention relates to blowers and this application is a continuation-in-part of my application Ser. No. 274,360, filed April 19, 1963, now Patent No. 3,236,298.

The invention is especially, though not exclusively, concerned with blowers of the cross flow type, that is, blowers comprising a cylindrical bladed rotor mounted for rotation about its axis in a predetermined direction and defining an interior space, and guide means defining with the rotor an entry region and a discharge region, the guide means and rotor co-operating on rotation of the latter in said predetermined direction to induce a flow of air from the entry region through the path of the rotating blades of the rotor to said interior space and thence again through the path of said rotating blades to the discharge region. More especially but, once again, not exclusively, the invention concerns blowers of the cross-flow type wherein the guide means and rotor co-operate to set up a vortex of Rankine character having a core region eccentric of the rotor axis and a field region which guides the air so that flow through the rotor is strongly curved about the vortex core: such blowers will herein be designated "tangential" blowers and the characteristics of a preferred form of such a machine will be described in detail later.

The normal means for converting velocity to pressure energy is a diffuser, that is a duct which gradually increases in cross-section, going in the direction of flow. Diffusers are well known to have two defects. First, if the duct diverges too rapidly, flow will tend to break away from the walls, forming regions of random eddying which waste energy. Second, if, to counter the first defect the angle of divergence is reduced then energy is wasted in friction along the over-long walls. Normally a diffuser is designed as a compromise to minimise these opposite defects. The angle of divergence is usually small, say 15°, so that a conventional diffuser is commonly bulky. A conventional diffuser is also well known to be subject to appreciable energy loss.

The invention is based on the appreciation that diffuser performance can be improved and/or its size can be reduced by placing one or more vanes at the narrow end of the diffuser, the vane or vanes dividing flow in the diffuser so that this flow takes place through a number of diffuser portions.

It has been proposed to divide a diffuser by intermediate walls into a plurality of diffusing channels, for example, in British Patent 876,611. One aim of this arrangement has been to enable the walls of each channel to diverge at the maximum angle and thus to enable the divergence of the diffuser as a whole to be increased. However, in practice the intermediate walls introduce friction and energy losses which militate against optimum performance.

An important feature of the present invention is that in contradistinction to the arrangement just mentioned the vanes terminate well short of the downstream end of the diffuser. Preferably the vanes extend over only a fraction of its length, say a quarter or a tenth. Such vanes introduce a minimum of additional friction and enable a substantial increase in the divergence of the diffuser without increasing the energy losses.

If the blower comprises a bladed cylindrical rotor, the diffuser will in general be rectangular as seen in section

take prependicular to flow, with opposite walls parallel to the rotor axis. The vane or vanes in this case will be straight and may be parallel to the rotor axis. If the rotor is of the propeller type, the diffuser will in general be circular in outline as seen in section taken perpendicularly to flow, and the vane or vanes will be annular.

The invention may be utilized with means producing resistance to flow (and hence a pressure drop) either at the suction side or at the pressure side or both, though in some cases having the resistance means on the pressure side will be preferred. As will be appreciated from the foregoing the invention can bring about a reduction in overall size due to a shortening of the diffuser or improvement of its efficiency.

One particularly compact arrangement according to the invention comprises a pair of similar "tangential" blowers arranged parallel side by side and discharging into a common symmetrically placed diffuser having vanes parallel to the rotor axes at its narrow end and resistance means, for example a heat exchanger, at its wider end. This arrangement has the effect of evening out the "peaky" velocity profile peculiar to the "tangential" blower while ensuring flow of substantial velocity adjacent the diverging diffuser walls. The vanes enable a substantial increase in the diffuser angle.

Various embodiments of the invention will now be described by way of example with reference to the accompanying somewhat diagrammatic drawings:

FIGURE 1 is a transverse section of a heat exchanger-blower combination incorporating a "tangential" blower with a diffuser having vanes at its upstream end, according to the invention;

FIGURE 2 is a side elevation of the FIGURE 1 unit with a part removed;

FIGURE 3 shows a pair of curves illustrating the functioning of the unit of FIGURES 1 and 2;

FIGURE 4 is a cross sectional view of a second form of "tangential" blower according to the invention;

FIGURE 5 is a perspective view, with parts cut away, of an axial blower having an annular vane at the upstream end of a diffuser, and

FIGURE 6 is a sectional view showing a modification of the diffuser illustrated in FIGURE 5.

Referring to the drawings, the apparatus of FIGURES 1 and 2 comprises a series of conduits **1** arranged in the form of a rectangular heat exchanger block designated generally **2** and running in parallel spaced relation between a pair of headers **3**, **4** at opposite shorter sides of the block. Fluid to be cooled is supplied to one header **3** and flows through the conduits to the header **4**.

A blower is provided to blow air through the thickness of the block **2**; the blower includes a pair of similar rotors **5**, **6** each having blades **7** arranged in a ring extending parallel to the axis between end discs **8** carrying stub shafts **9** whereby the rotors are mounted for rotation in bearings (not shown) in plane parallel end walls **10** of the unit. One stub shaft **9** of each rotor carries a pulley **11**: a belt (not shown) driven by an electric motor or other drive means (not shown) is trained over the pulleys so as to rotate them in opposite directions as shown by the arrows **12**. The rotors **5**, **6** have their axes parallel to the longer sides of the block **2** and their length is equal to that of the block.

The longer sides of the block **2** are enclosed by parallel walls **13** which are continuous with similar opposed guide walls **14** extending up to those sides from adjacent the corresponding rotor **5**, **6** and joining the end walls **10**. Each guide wall **14** is return-bent adjacent the rotor to provide a smaller vortex-stabilizing portion **14*a*** convergent with the rotor in the direction of rotor rotation and a larger diffuser wall portion **14*b***. The wall portions **14*b*** diverge at an angle of approximately 90° and form, with the end walls, a wide-angle diffuser **14**c having a throat portion at the upstream or narrow end of the diffuser. A symmetrical central guide wall **15** also extending between the end walls **10** provides two curved portions **16**, **17** facing the rotors **5**, **6** diverging steadily therefrom, and meeting at a sharp angle.

In operation of the unit the blades **7** of each rotor **5**, **6** (which will be seen to be concave facing in the direction of rotation with their outer edges leading) co-operate with the vortex-stabilizing guide wall portion **14**a to set up a cylindrical vortex which is eccentric to the rotor axis, the core of this vortex being indicated at V. Air is consequently guided twice through the path of the rotating blades **7** of each rotor **5**, **6** as indicated by the flow lines MF, F: the vortex causes the flow lines to curve in arcs centred approximately on the core centre, and also causes flow in the line MF, which passes adjacent the core, to be much faster than the flow at the other side of the rotor. For a fuller exposition of the way in which flow takes place reference should be made to British patent specification No. 876,611. Reference should also be made to U.S. Patent No. 3,150,816 as showing flow machines with a pair of contra-rotating rotors; those machines differ in various respects from that here shown, however, and have no diffuser or vane therein.

Air which has passed the rotors **5**, **6** enters symmetrically into the diffuser **14**c and passes through the thickness of the block **2**. Small vanes **18** supported between the end walls **10** are provided in the narrow or upstream end of the diffuser, to assist the flow.

The vanes **18** divide flow into the diffuser and form diffuser portions **18**a through which the divided flow passes.

Now from the foregoing it will be seen that the velocity profile at the section A—A of FIGURE 1 (that is, as the flows from the two rotors **5**, **6** join just after leaving those rotors) will be shaped somewhat as the curve A in FIGURE 3. Thus the fastest flow through the diffuser will be adjacent the wall portions **14**b. This will tend to reduce break-away losses, but the speed of the air adjacent the wall will nevertheless be reduced by friction while the speed remote therefrom is less reduced. As a result, at the section B—B of FIGURE 1 (that is, just before reaching the block) the velocity profile will approximate to the curve B of FIGURE 3. The speed of the air entering the block **2** will thus be approximately uniform over the whole area of the block, which enables optimum cooling. Due to the diffuser effect the pressure at the section B—B is higher than would be possible in the arrangement hitherto known and described above, so that by reason of the present invention the block can be thicker and/or more closely packed wtih conduits than would formerly have been desirable, thus leading to improved economy of space and material.

The rotors **5**, **6** need not be of great diameter and can with advantage be driven at speeds of the order of 1,500 r.p.m. so as to use electric motors which are relatively small and cheap. Any convenient drive arangement can be used, and instead of driving the rotors from a single motor a pair of similar motors connected to the same supply can be used instead.

It is to be noted that the angle of the diffuser is unusually wide, that such a wide angle can advantageously be employed is at least partly due to the presence of the vanes at the narrow end of the diffuser. This wide angle in turn leads to a compact and efficient structure.

FIGURE 4 shows a "tangential" fan, designated generally **40** and delivering air to a diffuser **41**; the fan includes a rotor similar to the rotor **5** of FIGURE 1 and guide means comprising end walls **42** aligned with the ends of the rotor and guide walls **43** and **44**. Guide wall **43** is similar to guide wall **14** of FIGURE 1, and guide wall **44** diverges steadily from the rotor going from a line of nearest approach thereto opposite the guide wall **43**. The guide walls **43** and **44**, with the end walls, define the diffuser **41** wherein the walls **43** and **44** diverge with respect to each other and wherein the narrow portion of the diffuser forms a throat portion. At the narrow end of the diffuser, half way between the walls **43** and **44** and parallel thereto, is positioned a vane **45**. As in the previous embodiment, this vane assists flow in the diffuser.

The invention can be applied to centrifugal and axial blowers in addition to "tangential" blowers. FIGURE 5 illustrates an axial blower **50** supported coaxially within a cylindrical duct **51**, which, downstream of the blower is belled out to form a conical diffuser **52** having a throat portion at its narrow upstream end. The annular vane **53** is supported on the spider **54** at the narrow end of the diffuser, to divide flow therein.

FIGURE 6 shows a modification of the FIGURE 5 apparatus, where an axial blower (not shown) blows air into the diffuser **60**. At the narrow end of the diffuser is positioned a series of coaxial annular vanes **61** designed so that the space **62** between each adjacent pair, and the space between the outer vane and the diffuser wall each act as a diffuser portion.

I claim:

1. A blower comprising a bladed rotor, guide means providing an inlet and outlet for said blower and cooperating with said rotor in operation to provide a flow of air through said inlet and outlet, an outwardly flared diffuser having a narrow neck portion adjacent one end joining with the outlet of said blower and having a diffuser outlet at the opposite end thereof, and at least one vane positioned within said diffuser in the neck portion thereof to divide flow therein and to form diverging diffuser portions on either side of the vane and wherein the vane extends only along a minor portion of the length of the diffuser.

2. A blower according to claim **1** wherein the rotor is a bladed cylindrical rotor and the duct is rectangular in cross section taken perpendicularly to flow with the width of said duct substantially equal to the length of the rotor and wherein the vane extends parallel to the rotor axis.

3. A blower according to claim **2** having two rotors and wherein said diffuser is positioned symmetrically with respect to both rotors.

4. A blower according to claim **1** wherein the rotor is of the axial flow type and said duct is aligned on the rotor axis and is circular in cross section taken perpendicularly to said axis with a radius which increases in the direction of flow through said duct, and said vane is annular and concentric with the rotor axis.

5. A blower comprising a bladed cylindrical rotor mounted for rotation about its axis and having an interior clear of stationary guides, guide means extending the length of the rotor which guide means define a suction region and a pressure region and which cooperate with the rotor on rotation thereof to induce a flow of air from the suction region through the path of the rotating blades to the interior of the rotor and hence again through the path of the rotating blades to the pressure region, a diffuser receiving air discharged from the rotor at said pressure region and having upper and lower walls which as seen from the side of the blower diverge with respect to each other in the direction of flow through the diffuser and wherein the narrow part of the diffuser forms a throat portion, means providing a resistance to flow at the downstream end of the diffuser, and at least one vane within the throat portion of the diffuser situated between said upper and lower walls and extending generally in the direction of flow in said diffuser less than the length of the diffuser, said vane dividing flow in the diffuser to form diffuser portions at either side of the vane.

6. A blower according to claim **5** comprising a plurality of vanes dividing flow in the throat part of the diffuser and forming a plurality of side by side diffuser portions.

7. A blower according to claim **5** wherein said resistance means comprises a heat exchanger.

8. A blower comprising a bladed cylindrical rotor mounted for rotation about its axis and having an interior clear of stationary guides, guide means comprising end walls substantially aligned with the ends of the rotor and first and second guide walls extending generally parallel to the rotor axis as seen in longitudinal section which guide means define a suction region and a pressure region and cooperate with the rotor on rotation thereof to set up a vortex of Rankine type having a core region adjacent said first guide wall, said vortex inducing a flow of air from the suction region through the path of the rotating blades to the interior of the rotor and thence again through the path of the rotating blades to the pressure region with said flow of air following lines which are curved about the vortex core region, said guide walls diverging outwardly from each other in the direction of flow from said rotor to form an outwardly flared diffuser with the narrow part of the diffuser forming a neck portion and the opposite end forming a diffuser outlet with said neck portion receiving air discharged from the rotor at said pressure region, means providing a resistance to flow at the outlet of the diffuser, and at least one vane positioned within the neck

portion of the diffuser and extending substantially parallel to said guide walls as seen in longitudinal section and along a minor portion of the length of the diffuser with said vane dividing flow in the diffuser, and the guide walls as seen in transverse section both diverging from said vane going in the direction of air flow in the diffuser where the angle of divergence of said first guide wall with respect to said vane is greater than the angle of divergence of said second guide wall with respect to said vane.

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